

Dynamical segregation of galaxies in groups and clusters

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ABSTRACT

We have performed a systematic analysis of the dynamics of different galaxy populations in galaxy groups from the 2dFGRS. For this purpose we have combined all the groups into a single system, where velocities v and radius r are expressed adimensionally. We have used several methods to compare the distributions of relative velocities of galaxies with respect to the group centre for samples selected according to their spectral type (as defined by Madgwick et al., 2002), b_j band luminosity and $B-R$ colour index. We have found strong segregation effects: spectral type I objects show a statistically narrower velocity distribution than that of galaxies with a substantial star formation activity (type II-IV). Similarly, the same behavior is observed for galaxies with colour index $B-R > 1$ compared to galaxies with $B-R < 1$. Bright ($M_b < -19$) and faint ($M_b > -19$) galaxies show the same segregation. It is not important once the sample is restricted to a given spectral type. These effects are particularly important in the central region ($R_p < 0.5 R_{vir}$) and do not have a strong dependence on the mass of the parent group. These trends show a strong correlation between the dynamics of galaxies in groups and star formation rate reflected both by spectral type and by colour index.

Key words: methods: statistical – galaxies: clusters: general – galaxies: kinematics and dynamics – galaxies: evolution

1 INTRODUCTION

Galaxy properties can be affected by several mechanisms in groups or clusters. The fact that different galaxies can be modified to a different extent, could give rise to observable segregational effects. By studying these effects, we may obtain valuable information on the way in which these mechanisms act on galaxies and drive their evolution.

The morphology density relation (Oelmer 1974; Dressler 1980; Andreon et al. 1996) is the best known segregational effect. Early type galaxies are more concentrated in denser regions, and lie closer to the centres of the clusters than late type galaxies. More recently, the clustering properties of galaxies have been found to be dependent on the characteristics of spectral features (Martínez et al. 2002; Domínguez et al. 2002; Biviano et al. 2002; Madgwick et al. 2003c), and luminosity (Benoist et al. 1996; Norberg et al. 2001, 2002; Stein 1997; Adami et al. 1997; Girardi et al. 2003).

Several mechanisms have been proposed to explain galaxy transformations. Their relevance are quite different according to the environmental conditions (Balogh et al. 2004) and so, their importance depends on the mass of the

clusters, and perhaps on the history of galaxy clustering (Gnedin 2003b). Some effects are more effective in dense regions like rich clusters, whereas in groups of galaxies other mechanisms play the most important role.

Ram pressure (Gunn & Gott 1972) can inhibit star formation by exhausting the gas present in galaxies that move fast in the intergalactic medium of rich clusters. Similarly, galaxy harassment (Moore et al. 1996) can produce significant changes in the star formation rate of a galaxy. These effects are not expected to be important in poor clusters or groups, where the velocity dispersion is lower, instead, effects such as mergers or tidal interactions can be dominant in these environments (Gnedin 2003a).

Besides affecting galaxy properties, such as star formation, luminosity and colour index, some of the physical processes listed above may also produce changes on the dynamics of the galaxy with respect to the cluster centre. In turn, the efficiency of some of these mechanisms to produce significant changes on a galaxy, depends on its dynamical behavior. For example, the effects of galaxy interactions are stronger for galaxies moving slowly with respect to the cluster centre. This suggests that the dynamical properties of galaxies in groups and clusters may be related

with the star formation efficiency, colours or luminosities of galaxies (Menci & Fusco-Femiano 1996; Moore et al. 1998). Segregation effects of galaxy velocities in clusters are predicted theoretically (Menci & Fusco-Femiano 1996; Gnedin 2003b), in semi-analytical models (Menci et al. 2002), and has been reported in rich clusters (Sodré 1989).

The relation between the dynamical properties and the luminosity of a galaxy has been observed in rich clusters, by e.g. Whitmore, Gilmore & Jones (1993); Adami et al. (1997) and Stein (1997), who find evidence for velocity segregation. In agreement with these findings, theoretical studies (Fusco-Femiano & Menci 1998) and numerical simulations (Yepes et al. 1991) show similar trends.

However, it is not clear how to interpret these results. Some authors propose different orbit shapes for galaxies with different morphologies or luminosities. In this scheme, early-type galaxies have quasi-isotropic orbits, while late-type galaxies move in nearly radial orbits (Benoist et al. 1997; Adami et al. 1997). However, other models have been proposed that contradict this statement (Ramírez & de Souza 1998).

Theoretical works predict virialized systems with a Maxwellian velocity distribution (Saslaw et al. 1990; Ueda 1993) so it has been proposed that early and late-type galaxies have Gaussian velocity distributions. However, observations in rich clusters do not support these hypothesis (e.g. Colles & Dunn, 1996).

The purpose of this paper is to explore for a possible difference in the dynamical behavior of galaxies with different spectral types, luminosities and colour indexes. The outline of this paper is as follows. In section 2 we describe the data sample used in our work, and in section 3, the method used in our analysis. Section 4 presents the results of our search for velocity segregation in spectral type, luminosity and colour. Finally, in section 5 we present a discussion of our results and future perspectives.

2 THE DATA

In order to analyse the dynamics of different galaxy populations in galaxy systems, we have carried out a systematic search for segregation effects of galaxies in velocity space. We have used a group catalogue constructed from the final version of the 2dF Galaxy Redshift Survey (Colles et al. 2001), using the same technique used by Merchán & Zandivarez (2002) to construct the group catalogue of the 2dFGRS 100K release (Folkes et al. 1999). This sample comprises 40978 galaxies in 5568 groups. Virial mass, velocity dispersion and virial radius have been determined for the groups in this sample.

Principal component analysis technique has been applied to all galaxies in the 2dFGRS by Madgwick et al. (2002). This technique allows to obtain the maximum possible spectral information with a minimum set of parameters, and so it offers a quantitative and efficient way to classify galaxies with a spectral index η . This index has a clear physical interpretation, since it is strongly related to the galaxy morphology (Madgwick 2003a), and correlates with the equivalent width of the H α line and with the star birthrate parameter (Madgwick et al. 2003b). These spectral parameters measure the strength of absorption features

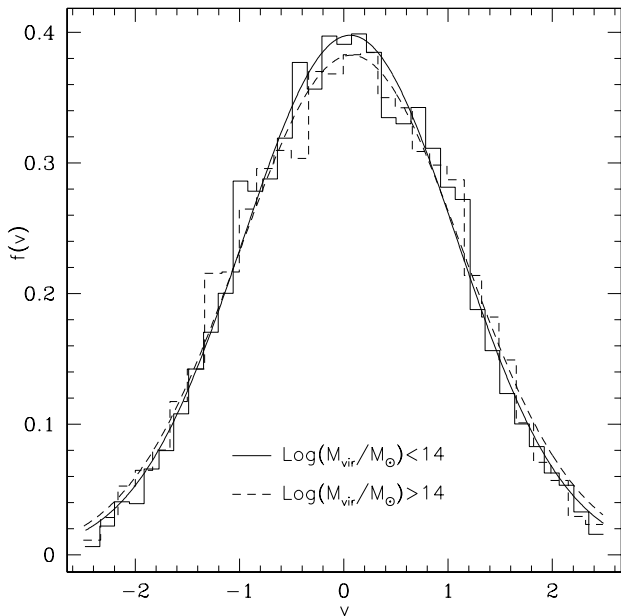


Figure 1. Normalized velocity distribution functions of relative velocities for two samples of galaxies selected according to membership to low ($< 10^{14} M_{\odot}$) and high ($> 10^{14} M_{\odot}$) parent cluster virial mass. Smoothed curves are Gaussian fits centered in $v = 0$.

by stars and ISM, and the strength of nebular emission features, making possible to obtain an idea of the relative contributions of different populations of stars. Negative values of η correspond to non star-forming galaxies, usually early type galaxies, whereas large values imply star formation features in the integrated spectra, typical of late type galaxies. Madgwick et al. (2002) defined 4 spectral types based on the shape of the distribution of η for galaxies in the 2dFGRS. Type I comprises all galaxies with $\eta < -1.4$; type II, galaxies with $-1.4 < \eta < 1.1$; type III, galaxies with $1.1 < \eta < 3.1$ and type IV all galaxies with $\eta > 3.1$.

The 2dFGRS also contains photometric information in the APM b_j band and in the super-cosmos b and r bands. This is a useful tool to study the dependence of a possible velocity segregation on galaxy luminosity and colour. Absolute magnitudes are denoted M_b , B and R . Distance dependent quantities are calculated using a Hubble parameter $H = 100 \text{ Km s}^{-1} \text{ Mpc}^{-1}$.

3 ANALYSIS

3.1 Ensemble group

In order to make a suitable analysis of the data, we have combined all the groups into a single system. In this ensemble, velocities v and radius r are expressed adimensionally. The line of sight velocities of each object ΔV , relative to the group average velocity, are scaled by the corresponding velocity dispersion σ of the host group. In a similar fashion, galaxy projected distance to the group centre R_p are scaled by its virial radius value R_v . This procedure allows for a simple and improved statistical treatment of the data and, assuming isotropy with respect to their centres, maintains spa-

case	samples	restriction	$\text{Log}(\mathcal{M}_v/M_\odot)$	r	N_1	N_2	L_{KS}	P_β	$P_{\Delta K}$
Spectral type segregation									
1	$\eta < -1.4$ vs. $\eta > 1.1$	all luminosities	all masses	< 1.2	8985	2561	$> 99.9\%$	< 0.001	< 0.001
2	$\eta < -1.4$ vs. $\eta > -1.4$	all luminosities	all masses	< 1.2	8985	6066	$> 99.9\%$	< 0.001	< 0.001
3	$\eta < -1.4$ vs. $\eta > 1.1$	all luminosities	all masses	< 0.5	7234	1803	$> 99.9\%$	< 0.001	< 0.001
4	$\eta < -1.4$ vs. $\eta > -1.4$	all luminosities	all masses	< 0.5	7234	4250	$> 99.9\%$	< 0.001	< 0.001
5	$\eta < -1.4$ vs. $\eta > 1.1$	$M_b < -19$	all masses	< 0.5	4086	603	$> 99.9\%$	0.001	< 0.001
6	$\eta < -1.4$ vs. $\eta > 1.1$	$M_b > -19$	all masses	< 0.5	3148	1200	$> 99.9\%$	0.001	0.004
7	$\eta < -1.4$ vs. $\eta > 1.1$	all luminosities	< 14	< 0.5	2430	916	99.9%	0.014	0.001
8	$\eta < -1.4$ vs. $\eta > 1.1$	all luminosities	> 14	< 0.5	4804	887	$> 99.9\%$	< 0.001	< 0.001
Luminosity segregation									
9	$M_B < -19$ vs. $M_B > -19$	all types	all masses	< 0.5	5770	5714	99.9%	0.001	< 0.001
10	$M_B < -19$ vs. $M_B > -19$	all types	all masses	> 0.5	1669	1898	85.0%	0.104	0.176
11	$M_B < -19$ vs. $M_B > -19$	$\eta < -1.4$	all masses	< 0.5	4086	3148	99.0%	0.052	0.007
12	$M_B < -19$ vs. $M_B > -19$	$\eta > -1.4$	all masses	< 0.5	1684	2566	91.2%	0.018	0.136
13	$M_B < -19$ vs. $M_B > -19$	$\eta > 1.1$	all masses	< 0.5	603	1200	54.0%	0.395	0.280
14	$M_B < -19$ vs. $M_B > -19$	all types	< 14	< 0.5	1841	2660	99.9%	< 0.001	< 0.001
15	$M_B < -19$ vs. $M_B > -19$	all types	> 14	< 0.5	3929	3054	94.1%	0.016	0.019
Colour index segregation									
16	$CI < 1$ vs. $CI > 1$	all types & luminosities	all masses	< 0.5	7291	4180	$> 99.9\%$	< 0.001	< 0.001
17	$CI < 1$ vs. $CI > 1$	all types & luminosities	all masses	> 0.5	1904	1663	94.0%	0.276	0.373
18	$CI < 1.2$ vs. $CI > 1.2$	$\eta < -1.4$	all masses	< 0.5	3583	3651	90.5%	0.158	0.239
19	$CI < 0.7$ vs. $CI > 0.7$	$\eta > 1.1$	all masses	< 0.5	805	998	66.2%	0.369	0.320
20	$CI < 1$ vs. $CI > 1$	$\eta > 1.1$	all masses	< 0.5	136	1666	45.3%	0.281	0.197
21	$CI < 1$ vs. $CI > 1$	$\eta < -1.4$	all masses	< 0.5	6361	866	99.8%	0.018	< 0.000
22	$CI < 1$ vs. $CI > 1$	$M_b < -19$	all masses	< 0.5	4121	1639	$> 99.9\%$	0.002	< 0.001
23	$CI < 1$ vs. $CI > 1$	$M_b > -19$	all masses	< 0.5	3170	2541	$> 99.9\%$	0.037	< 0.004
24	$CI < 1$ vs. $CI > 1$	all types & luminosities	< 14	< 0.5	2341	2154	$> 99.9\%$	0.013	< 0.001
25	$CI < 1$ vs. $CI > 1$	all types & luminosities	> 14	< 0.5	4950	2026	$> 99.9\%$	0.001	< 0.001

Table 1. Segregation effects in the 2dFGRS. We list the results for the three types of velocity segregations, analysed in this work. The different criteria used to divide the total sample are shown. Each case analysed has been labelled for its reference in the text. N_1 and N_2 are the number of galaxies in each subsample; P_β and $P_{\Delta K}$ are the probabilities of obtaining a value from synthetic data, of β or ΔK respectively, greater than that obtained on the data. L_{KS} is the level of significance with which the null hypothesis that the two samples were taken from the same distribution can be disproved, according to the Kolmogorov–Smirnov test.

tial and dynamical properties of the ensemble groups. Similar procedures have been implemented e. g. by Adami et al. (1997); Stein (1997) and Ramírez & de Souza (1998).

The virial radius is estimated from the projected distances of members to the group centre (Merchán & Zandivarez 2002). Uncertainties in these value, as well as in the determination of the centre of the system (derived by the unweighted mean of group member positions), can be larger for groups with few galaxies. Accordingly we have restricted all our analysis to groups with more than 10 members to reduce these uncertainties. In section 4.5 we analyse the reliability of our results related to this choice.

In order to explore the possible differences in the velocity distribution of galaxies between groups and clusters, we have divided the total sample of galaxies according to membership into low ($< 10^{14} M_\odot$) and high ($> 10^{14} M_\odot$) virial mass systems. In Fig. 1 we show the resulting velocity distribution functions $f(v)$ where it can be appreciated that both sets present remarkably similar distributions. This fact allows us to perform the same treatment to all groups irrespective of their mass. We notice, however, that the shape of this distribution is influenced by uncertainties in galaxy redshift determinations in the 2dFGRS. The rms uncertainty is approximately 85 km/s (Colles et al. 2001). In section 4.5 we explore the effect of these uncertainties in our analysis.

3.2 Analysis of the ensemble group

Our analysis is based on the comparison of normalized velocity distributions of galaxies in different samples, selected by spectral type (η), colour index (CI) or luminosity (quantified by M_b).

In order to test the presence of a difference in the dynamical behavior of two given samples of galaxies, we have adopted different procedures to deal with the velocity distribution functions $f(v)$. One of these methods is the Kolmogorov–Smirnov (KS) test (Press et al. 1986). In this method, it is possible to disprove, to a given level of significance, the null hypothesis that two distributions were taken from the same population distribution function.

We have calculated the difference ΔK between the values of the kurtosis of the two distribution functions. This parameter provides a useful characterisation of the velocity distributions since it is related to the relative fraction of galaxies with low velocity ($v < 1$) in each subsample objectively.

We have also binned the velocities in $|v|$, using 5 bins. The uncertainties in each bin have been determined using the bootstrap resampling technique. We defined a parameter β as the difference between the first bins of each distribution. The uncertainty of β is estimated by propagating individual errors for each bin.

We have constructed 1000 new samples drawn from the original data but reassigning spectral types, colour indexes

or luminosities. The distributions of these parameters mimics the ones of the original observed sample. For each one of these random samples we have determined β and ΔK . The resulting distributions of these parameters provide an estimate of the significance of the observed values in the real data, since these distributions can be used to calculate the probabilities P_β and $P_{\Delta K}$ of obtaining, in the random samples, values of β and ΔK greater than the observed ones. The resulting probabilities P_β , $P_{\Delta K}$ and the KS significance are shown in Table 1.

As previously mentioned, we have resampled sets of data using the bootstrap technique in order to estimate the reliability of the results. Explicitly, for each pair of samples we have calculated the variance of β and ΔK for the corresponding bootstrapped samples. This variance provides a reliable estimate of the uncertainties of the given parameter.

The large size of the data set has allowed us to explore the results for different subsamples of the data corresponding to different galaxy and group properties such as spectral types, luminosities, colour indexes, group centric distance and parent group virial mass. To achieve this goal we have applied the tests described above to the different subsamples.

4 RESULTS

4.1 Spectral type segregation

We have analysed the distribution functions of the relative velocities for subsamples of different spectral type index,

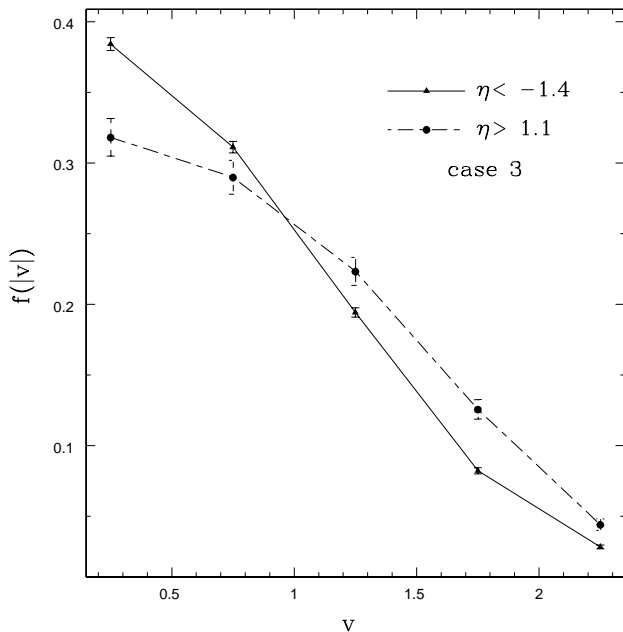


Figure 2. Normalized binned velocity distributions for early ($\eta < -1.4$) and late type ($\eta > 1.1$) galaxies within $R_p = 0.5 R_v$. Error bars have been calculated using the bootstrap resampling method. This plot corresponds to the case 3 in Table 1, which presents the strongest segregation.

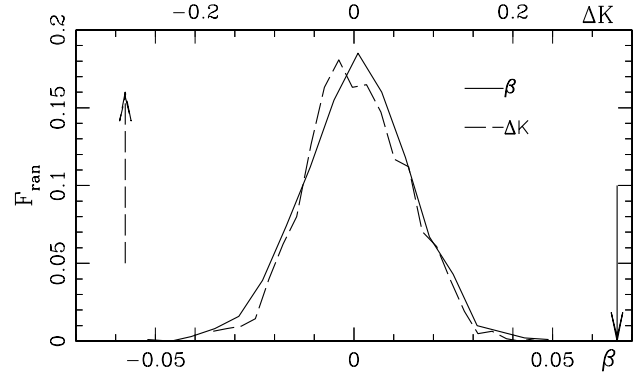


Figure 3. Distributions of β and δK parameters for 1000 random realizations for case 3 (type I vs. type III-IV; in the inner region). Arrows indicate the observed values of the corresponding parameters.

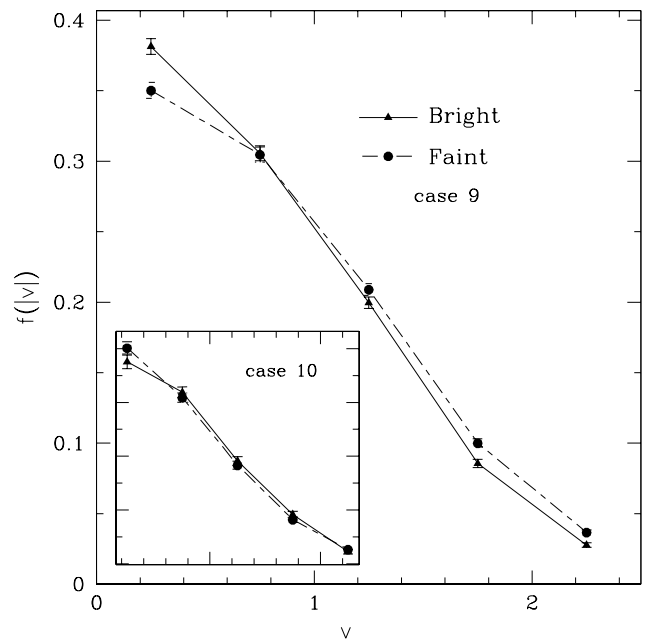


Figure 4. Normalized velocity distributions for bright ($M_b < -19$, solid line) and faint ($M_b > -19$, dashed line) galaxies within $r = 0.5$ (case 9). The inner plot shows the results obtained for a sample with $r > 0.5$ (case 10)

with no further restriction in galaxy luminosity or colour index. Figure 2 shows the velocity distributions $f(v)$ for type I and types III-IV galaxies, where the presence of a strong segregation can be clearly appreciated. The relative line of sight velocities of type I galaxies are statistically smaller than those of galaxies with a substantial star formation activity. To compute the statistical significance of the difference between these two distributions, we have applied the three tests described in the previous section. According to the KS test, we can disprove to a significance level greater than 99.9% that the two distributions are drawn from the same parent distribution. The distributions of the parameters β and ΔK obtained for 1000 random realizations are

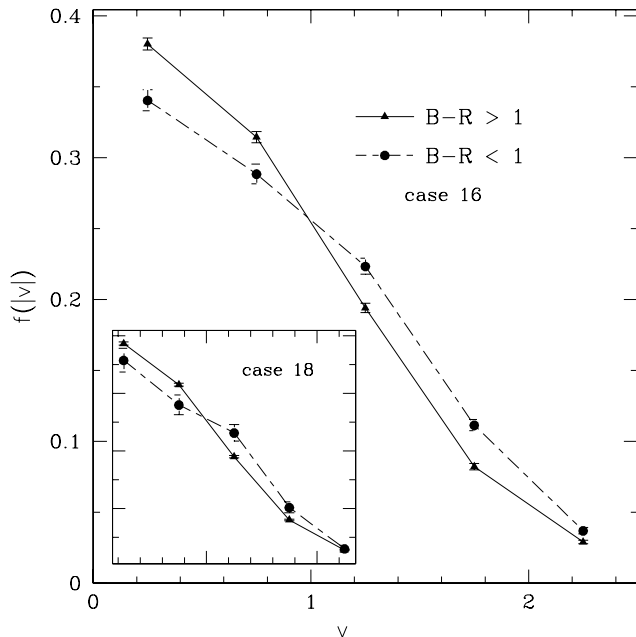


Figure 5. Normalized velocity distributions for red ($B-R > 1$, solid line) and blue ($B-R < 1$, dashed line) galaxies. The inner plot shows the results obtained for a sample restricted to type I galaxies

shown in Fig. 3, the arrows indicate the values obtained for the real data.

According to these results, velocity segregation by spectral type is very significant statistically, corresponding to a fraction of 69.5% of early type galaxies and 60.7% of late type galaxies within the group mean velocity dispersion ($v < 1$) with respect to the total number of galaxies in each subsample. These quantities may depend on the uncertainties on the determination of velocities, however, as is stated in section 4.5, this fact does not affect the observed trends.

Table 1 summarizes the results for spectral type segregation obtained by restricting the samples to a given galaxy luminosity and group centric distance, as well as different parent group virial mass. If we restrict our analysis to the inner region of the groups ($r < 0.5$), the segregation intensity is stronger, but it is similar for systems of different mass. These facts will be addressed in more detail in section 4.4

4.2 Luminosity segregation

We have searched for a possible velocity segregation by luminosity, by applying the same methods as in section 4.1. We find a significant difference of the normalized relative velocity distributions between bright and faint galaxies, as can be appreciated in Fig. 4. The luminosity cut adopted to define the two subsamples, $M_b = -19$, give a similar number of galaxies in both of them. We have also considered the central ($r < 0.5$) region of the groups, where it can be seen that the velocity segregation by luminosity is stronger (see Table 1). This trend is similar to the observed behavior of the segregation by spectral type, which is stronger in denser

environments (see section 4.1) and will be discussed in more detail in section 4.4.

Given the significant velocity segregation by spectral types, we have searched for luminosity segregation in subsamples restricted to type I and types III-IV galaxies. We find that the luminosity segregation signal is of less significance in these cases, indicating that luminosity is not a primary parameter in defining the dynamics of galaxies in groups. This suggests that early spectral type galaxies, on average more luminous than late types, could provide the observed dependence on luminosity.

4.3 Colour segregation

Using the same procedure we have also explored the relation between galaxy dynamics and colour index. We have considered the $B-R$ colour index provided in the 2dFGRS final data release for the galaxies in the group sample. Given the narrow range of redshifts in the group sample ($0.02 \lesssim z \lesssim 0.20$), a unique threshold is suitable to define a sample of red galaxies.

The normalized velocity distributions for red ($B-R > 1$) and blue ($B-R < 1$) galaxies are shown in Fig. 5, where a significant velocity segregation of velocity according to galaxy colour index can be clearly appreciated. Given the correlation between $B-R$ colour index and spectral index η , we have restricted our analysis to galaxies with low present star formation (type I), and strongly star forming galaxies (types III-IV). The results are shown in Table 1, and for type I objects in the small box of Fig. 5. As it can be appreciated, velocity segregation has a lower level of significance in the last case.

4.4 Dependence of segregation on global properties

In the previous section we have analysed the different dynamics of galaxies according to their intrinsic properties, namely spectral type, luminosity and colour index. Our results suggest that the segregation effects are stronger in denser environments although there is no indication of a strong dependence on the parent group mass. In this section we explore in more detail the dependence of our results on galaxy-group centric distance and parent group virial mass.

In Fig. 6 we show the dependence of the kurtosis differences ΔK on r . The dashed region displays the rms of the distribution of ΔK obtained for the random samples described in section 3.2. It can be clearly appreciated that velocity segregation in the central regions ($r < 0.5$) is particularly important for spectral type and colour index but smoothly decreases at larger group centric distances. In a similar fashion, we have analysed the dependence of velocity segregation on parent group virial mass. Our results for galaxies with $r < 0.5$ are shown in Fig. 7. It can be appreciated that there is no strong dependence of the segregation effects on the mass of the parent group. This is an important fact suggesting that the mechanisms that generate the observed difference in the dynamics, according to the galaxy star formation activity, are efficient on a wide range of masses.

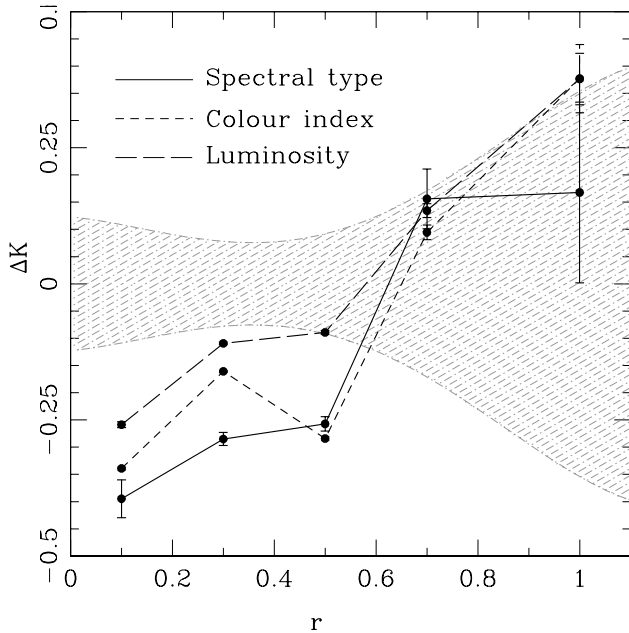


Figure 6. Dependence of the kurtosis differences ΔK on R_p/R_{vir} . The dashed region displays the rms of the distribution of ΔK obtained for the random samples described in section 3.2. Error bands are calculated using bootstrap resampling technique.

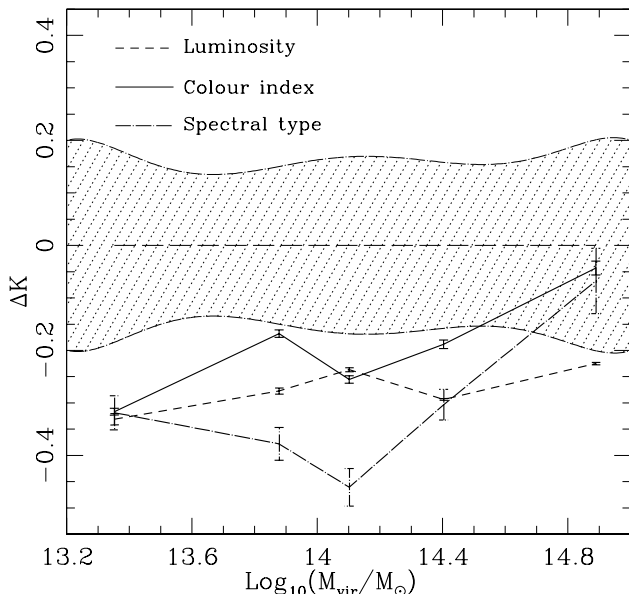


Figure 7. The same as Fig. 6 but for the dependence of ΔK on the virial mass of the parent group. The dashed region displays the rms of the distribution of ΔK obtained for the random samples. Error bands are calculated using bootstrap resampling technique.

4.5 Analysis of uncertainties

The uncertainty in redshift determinations in the 2dFGRS amounts to a rms of 85 km s^{-1} (Colles et al. 2001). This is a quite large figure, so its effects on our statistical analysis deserves particular attention. To account for this uncertainty we have convolved each line of sight velocity measurement with a Gaussian with dispersion $\epsilon = 85 \text{ km s}^{-1}$. The resulting smoothed histograms are suitable to compute the parameters characterizing the differences of the distribution of velocities of two given samples of galaxies taking into account line of sight velocity errors. As an example of this analysis, in Fig. 8 we show the results for case 3, where it can be appreciated that the binned and the smoothed distributions show the same behavior. Moreover we have computed the parameters β and ΔK for the cases shown in Table 1, finding similar results which show the stability of our analysis against redshift measurements errors.

As a test of the stability of our results against the number of group members, we have also analysed a sub-sample of groups restricted to have at least 20 members. We obtain similar and even more prominent segregation effects for the same galaxy properties analysed previously. Also, in order to test the effects of possible erroneous determination of the centre of the groups in our results, we have repeated the analysis for re-centered groups. These new centres were calculated using only galaxies within 1.2 times the virial radius and 2.5 times the velocity dispersion, which would provide a better estimate of group centres for elongated or clumpy systems. Again here the results are similar and show that our conclusions are not strongly dependent on the group centre definition.

5 DISCUSSION

We find a statistically significant difference of the distributions of group centric line of sight velocities, normalized to the group mean velocity dispersion, for samples of galaxies selected by spectral type, luminosity or colour index. Given the large data set analysed, we have been able to investigate the dependence of this velocity segregation on group properties and galaxy-group centric distance. Spectral type I objects, corresponding to passively star forming galaxies, show a statistically narrower velocity distribution than that of galaxies with a substantial star formation activity (types III-IV). Similarly, samples of galaxies with greater colour index ($B-R > 1$) have a larger fraction of small velocities ($v < 1$) compared to galaxies with $B-R < 1$. These two trends show a strong correlation between galaxy dynamics in groups and star formation, reflected both by spectral type and by colour index.

The velocity distribution of luminous galaxies (typically brighter than $M_b = -19$) also show a larger fraction of small velocities, although we notice that once the galaxies are restricted to a given spectral type, there is a less significant segregation. Thus, luminosity is not likely to be a primary parameter determining galaxy dynamics in groups. Our results suggest that the observed luminosity segregation might be related to the fact that the slowest objects, of early spectral type, are on average more luminous than star forming galaxies.

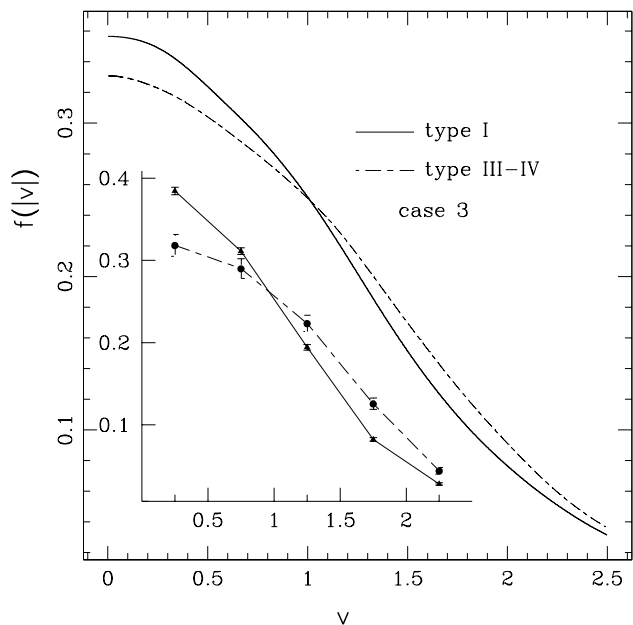


Figure 8. Normalized velocity distributions convolved with a Gaussian of width 85 Km s^{-1} . Inside box shows the binned case for comparison.

There are several mechanisms that may produce dynamical segregations of galaxies in groups and clusters. Ram pressure can effectively remove the existing gas in the galaxies and transform star forming into passively star forming objects. This mechanism affects most strongly those galaxies with large velocities with respect to the intra-cluster medium, and then it should produce a dynamical segregation with opposite trends to the observed one. Moreover, since our analysis concerns groups and small clusters of galaxies, ram pressure is not expected to be significant. Our results indicate that the velocity segregation effects are nearly independent of group virial mass. This fact also suggests that ram pressure is not important since its effects are stronger in more massive systems, and with higher velocity dispersion. Thus, it is unlikely that ram pressure may explain the observed correlations.

Mergers on the other hand, are effective to generate spheroidal objects with a low star formation rate. Galaxy encounters are expected to lower the original cluster-centric relative velocities of each galaxy, with respect to the velocities of the galaxies prior to the merger event, so that they can act effectively in generating the observed trends.

In a similar fashion, tidal interactions may effectively remove a substantial amount of gas from disks of galaxies, and then, are also effective in truncating star formation. Early type objects generated through this mechanism, would be biased to smaller velocities since interactions are expected to be more effective in slow encounters. Furthermore, these are generally brighter and redder objects.

It has been suggested that morphological transformation of galaxies takes place in systems which have a density threshold larger than the density of groups and poor clusters of galaxies (Moore et al. 1996; Gray 2004). Our results indicate that dynamical segregation of passively star forming

galaxies is a generic feature of systems of galaxies, irrespective of global properties. However, the fact that segregation effectively occurs in the inner regions of groups indicates that density might be an important parameter in determining the observed effects.

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